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ABSTRACT

This paper describes the state of the "WWW & Over" project to design techniques for the remote control of hypermedia teaching materials. It reviews the main features of the new version of the prototype for distance teaching, where teacher and students interact at a distance in real time on teaching materials created by the teacher. Also described are the first experiments in real distance-teaching processes during a university course, the results of which show that transmitting the video image of the teacher--which is normally regarded as crucial for recreation of the "real" classroom--is not, in face, indispensable. It was found instead that the teacher's voice and its coordination with his/her actions is essential for the success of a distance lesson. Since the project has applicative purposes in environments consisting of low-cost and low-performance networks, this finding on the one hand encourages experimentation with the techniques adopted by "WWW & Over," while on the other, it rules out the use of numerous systems based on audio/video streaming in view of the substantial delay that arises between the real event and its perception by users. (Contains 11 references.) (Author/AEF)

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ED 466 146

The WWW&OVER project: real-time distance education and the role of the Street Singer

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Abstract

The paper describes the present state of the WWW & Over project to design techniques for the remote control of hypermedia teaching materials. It reviews the main features of the new version of the prototype for distance teaching, where teacher and students interact at a distance in real time on teaching materials created by the teacher. Also described are the first experiments in real distance-teaching processes during a university course, the results of which show that transmitting the video image of the teacher – which is normally regarded as crucial for recreation of the 'real' classroom – is not in fact indispensable. It was found instead that the teacher's voice and its coordination with his/her actions is essential for the success of a distance lesson. Since the project has applicative purposes in environments consisting of low-cost and low-performance networks, this finding on the one hand encourages experimentation with the techniques adopted by WWW & Over, while on the other it rules out the use of numerous systems based on audio/video streaming in view of the substantial delay that arises between the real event and its perception by users.

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Introduction

Perhaps still to be found in Sicilian popular culture are the *cantastorie*, strolling minstrels who comment in song on news events depicted on painted placards. Teachers who project slides during a classroom lesson are in the same technical situation as the *cantastorie*. Though there is a substantial difference between them, we shall show that it has no bearing on our argument. The *cantastorie* uses his voice to sing, while a teacher more simply performs an oration in prose. In the beginning was the blackboard; then came film strips, OHP transparencies, slides, the video recorder, and finally, and inevitably, the computer. Each of these devices has its place in the expounding of arguments for didactic purposes. If we concentrate on the applied context in which topics are expounded by means of computer, we find that the lecturer, like the Sicilian street singer, manoeuvres the visualization of images to reinforce the arguments expounded in his/her oration. At the same time the lecturer, again like the *cantastorie*, uses images to give coherence to his/her discourse. In this case, the images provide guidance for the lecturer during his/her oration. During the lecture, the lights in the room are usually dimmed to give sharpness to the images projected, and the lecturer is usually hidden behind a computer monitor. It is generally believed that this state of affairs does not greatly affect the nature of a frontal lesson characterized by the physical presence of the teacher in the room. As a consequence, the majority of the approaches tend to virtualize the teacher's image by transmitting television pictures in order to recreate direct classroom communication between teacher and students at a distance.

The results presented in this paper suggest, however, that the teacher's virtual presence depends much less on his/her image than on his/her voice [Land et al, 1999], [Kötter et al, 1999]. During the last academic year, part of a course at our University was taught entirely at a distance. The students were from two different faculties but they attended the same course (Introduction to Databases), one-third of which was taught without the lecturer being physically present in the classroom. The teacher was alternately present in one of the two classrooms in the two faculties, and his image was projected in the other classroom (30 kilometres away) by means of a simple telephone link. The lesson was piloted by the prototype briefly described in section 2 of this paper. Besides the technical results, the feature that we believe warrants most detailed analysis is the feedback provided by the students (around 50 of them) at the end of the course. Put briefly, it emerged that the role of the lecturer as *cantastorie* (image, expressions, gestures) is less influential than, and because of, the interest aroused in the listeners by his/her voice.

2. A prototype for real-time online learning

Distance teaching has for years been a central concern of the training community, but it is still not as widely used as would be desirable. The association between the World Wide Web and distance learning is by now well-established, and many products for the creation and management of teaching materials for use on the WWW are now available [Becher et al., 1999],[Mioduser et al., 1999]. Thanks to the growth of the Internet, numerous users are able to exploit the potential of the Web [Bos et al., 1996]. But although the Web allows the rapid transmission of multimedia lessons and the easy and rapid updating of information and materials, it does not solve the problem of lesson management. Besides the speed of transmission lines, the technology amply meets the needs of the large-scale use of distance learning, but there are still numerous problems connected with the 'pull' metaphor typical of the WWW [Colazzo et al., 1996]. A further critical aspect is the difficulty faced by teachers in the rapid production of teaching materials, if they are not IT experts and are unacquainted with specialized tools [Ibrahim et al., 1995],[Ehner et al, 1999]. The distance between teacher and student creates obvious problems, because the physical relationship that arises in a 'real' classroom cannot be easily recreated in a 'virtual' one where teacher and student

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are not in physical contact. But the main criticism of the model of distance education that predominates today, based mainly on the WWW, springs from the following simple consideration. Students cannot be assigned control over their learning process by being allowed to navigate unsupervised among the teaching materials. This is because the students' lack of knowledge prevents them from distinguishing the most important concepts and from navigating in accordance with the teacher's wishes [Ping-Jer Yeh et al., 1996]. Only the teacher who has prepared the lesson knows which is the best route, which concepts should be memorized, which points may be ambiguous, and so on.

The aim of the WWW&Over project is to create a tool for the delivery of multimedia lessons via Internet which enables the teacher to exert more direct control over them. The system derives from a project begun in 1993 [Colazzo et al., 1995] in which the interactivity is created via a TCP/IP peer-to-peer network comprising the teacher's computer and the student computers linked thereto. This type of link is currently enjoying enormous success, especially in the area of file-sharing via Internet (Napster™ being a case in point). Under our approach, teacher and students are able to interact during a lesson without being physically present in the same place. The system enables the teacher to intervene in his/her multimedia lesson from his/her work station, while the students' computer screens show the slides and the teacher's actions at that particular point of the lesson. It thus simulates physical presence in the classroom, flanked by the broadcast voice and image of the teacher via videoconference and by an events management system (control console) used only by the teacher during the lesson. Our initial preoccupation when flanking our prototype with a videoconferencing system to broadcast the teacher's image/voice naturally concerned the bandwidth of the latter. In fact, although the purpose of the prototype was to minimize this aspect, the broadcasting of video in real time proved to be a problem. The findings of the experiment are interesting, given that it used was a 160x120 pixel image. The main impact of the prototype was the creation of a lesson environment which approximated a 'real' classroom as closely as possible, and thereby enabled the teacher to use multimedia technology without having to equip the classroom with videoconferencing equipment that the majority of teaching institutions are unable to afford. The solution was based on the use of standard communication protocols like TCP/IP. This makes it possible to distribute a single version of the application to both teacher and students and to use the teaching hypermedia differently according to the mode chosen. In this way, all the material used during the lesson is directly available to the students on their hard disks, so they do not have wait, for example, while an animation is being downloaded, as instead happens with Web-based courses.The WWW&Over project is a multi-year project and therefore consists of numerous components. Here we shall analyse only its part relating to real-time lessons. This part has been called the '**Control Console/Panel**', the distinctive features of which are now listed:

- the possibility of creating a remote lesson as similar as possible to the traditional frontal lesson by connecting a telecamera to the student computers to gain visual surveillance of the whole class:
- the limited use of network resources made possible by the presence already in the student computers of the multimedia teaching materials (sounds, images, film clips, etc.): these are not transferred, merely 'piloted';
- the use of *de facto* standards for the transmission (TCP/IP) and of an *ad hoc* protocol for managing the distance lesson;
- simplification of on-line connections by users;
- different modes of use (on-line, off-line, teacher mode, student mode): this allows the student to use the materials for self-study as well;
- different visualizations on the teacher's application and the student's screen, so that the former can monitor the current state of the latter;
- multi-user integrated electronic communication system (Chat), with messages differentiated for all students or for only some groups, or person-to-person communications;
- interaction on the materials between teacher and students, with role reversals, direct question-asking via the slides, the highlighting of parts of the slides, etc.;
- recording the actions made by the teacher and/or students on the teaching materials.

2.1 Salient aspects of the prototype

The system comprises two distinct parts.

- The authoring system, where lessons are created using an editor similar to Powerpoint™ but simplified in those parts less suited to didactic purposes and with emphasis on giving dynamism to the lesson. The authoring system was created with Toolbook, a widely-used multimedia authoring system of which the multimedia creation functions have been utilized. This part of the system is not described here.
- The reader system, i.e. the component of the prototype which reads the lesson and enables the teacher to use it. This component is described in what follows.

For the moment the prototype is in Italian. As said, the multimedia teaching materials produced by the authoring system are previously distributed to the students. Thus, when the application is opened, the system asks the user what type of role s/he wants to perform during the lesson (fig. 1). The student is also asked for his/her IP address or the name of the remote host with which the teacher is waiting to be connected. The system is therefore heavily based on the idea which is today called peer-to-peer, also because we believe this to be a winning approach in a didactic environment. Already in its early versions [Colazzo et al., 1998] the system used a 'push' approach, given that, as said, the pull model is unsuited to on-line training environments.

Fig 1 Choosing the role played in the lesson

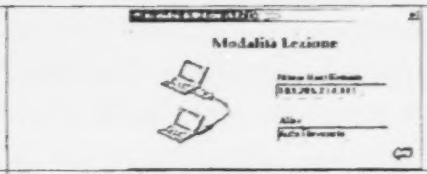

Fig 2 The connection to the teacher's computer

The prototype's network configurations are of substantially two types:

- in the first, the students', i.e. the 'clients' are directly connected to the server, the teacher's application;
- in the second, there is an intermediate node – the Repeater – between client and server.

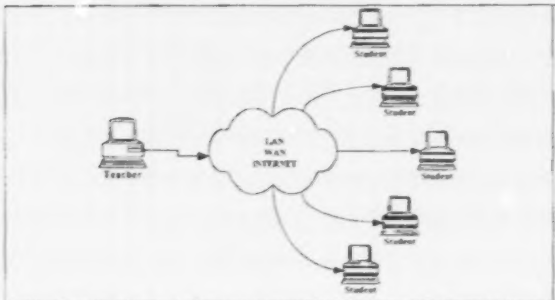

Fig 3 The prototype with teacher and students directly connected

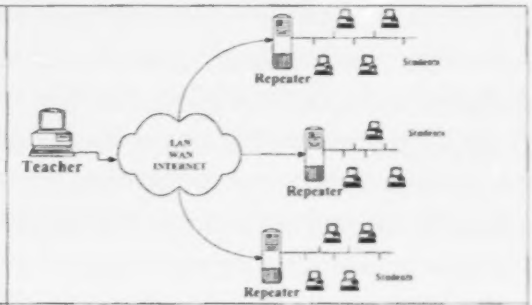

Fig 4 The prototype with different classrooms using repeaters

In the former case, a star-shaped structure is used which concentrates all the connection management operations on the server (the teacher's computer). This structure can be used efficiently only when there are a few clients. In the presence of numerous clients, transmissions between server and clients can be mediated by the Repeater. The latter is an application which sends the messages from the Server to the clients and vice versa. By means of the Repeater, the teacher's application can handle the transmission of data more efficiently and rapidly, given that the number of connections is relatively small. Most of the workload, in fact, is borne by the Repeater, the sole function of which is to handle connections and to duplicate data for each client.

2.2 Managing the lesson in real time

Once the lesson has been created and its dynamism established by the prototype author, at the beginning of the lesson the teacher exercises complete control (should s/he want it) over everything in the work environment depicted in figure 1 by means of the 'control console' shown in figure 5. The teacher can also use a navigation bar, which is naturally not visible to the student until s/he asks to intervene. Besides the navigation bar, the teacher can use the sequencer, which is the lesson 'control panel' real and proper (fig. 6). The Sequencer organizes the lesson pages with their objects into the sequence defined by the teacher. Each item in the sequence can be easily identified by the name given to it by the teacher or created automatically by the system.

Activation of the service: the teacher accepts connections from the students
Visualization, management and control of current connections
Device which sequences the actions to be performed during the lesson
Lesson mode developed *ad hoc* by the teacher
Use of the multi-user Chat
Clearance for intervention in the lesson by users
Management of slide/object transition effects

Fig. 5 Control Console of the prototype and explanation of the buttons

An icon determines the visualization status of an object, so that an object in the sequence can be:

Alway visible	Currently visible	Currently hidden

The teacher can therefore use the sequencer to follow the sequence of objects created at the authoring stage, or s/he can vary it according to his/her wishes. When a particular slide is being shown, the situations on the computer

screens of the teacher and students may be the ones presented in fig 7 and 8. Note the highlighting of the elements already visualized, and also of the next element in the sequence. This gives the teacher a series of advantages while s/he conducts the lesson and transmits information to the students.

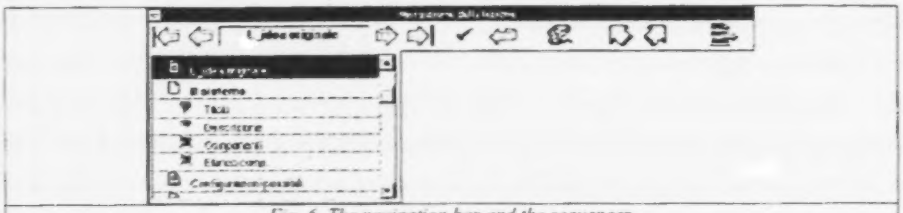

Fig. 6. The navigation bar and the sequencer

- The teacher can choose what to let the students see and what not to let them see.
- All the elements on the slide can be visualized to maintain the sequence of the argument, unlike in the case of presentation products, where what the speaker sees is also what the audience sees. This engenders less cognitive overhead for the audience because they only see the objects being discussed by the teacher at that moment.
- The lesson control tools are only visualized on the teacher's computer, so that the students' screens are not cluttered with buttons, arrows, cursors, and so on. This, too, reduces the students' cognitive overhead and enables them to concentrate solely on the slide.
- Only some of the elements on the slide can be re-viewed, an option which is extremely useful in the management of animations, for example.
- The teacher can jump to slides other than those in the sequence without the student noticing. S/he can thus change the route through the material without the students realizing, deciding impromptu the next slide to show.
- The presence on the teacher's computer of other software for example a word processor program with the written text of the lesson – without disturbance to the student.

3. The experiment

The experiment in teaching the 'Introduction to Databases' course at a distance was conducted at the University of Trento's two campuses located in Trento and Rovereto. Involved in the sessions were around 50 students, who divided between economics/business studies and information engineering. The students were attending the course for completely different reasons, given that it was a compulsory course with compulsory attendance for the information engineering students and an optional subsidiary course for those attending the economics faculty. This radical difference in motivation was extremely useful for creating a sample of potential on-line learners that was as heterogeneous and complete as possible. During the sessions the teacher was assisted by three other persons (two of them in the remote classroom) who helped with preparation and management of the lesson and dealt with technical problems without interrupting its progress.

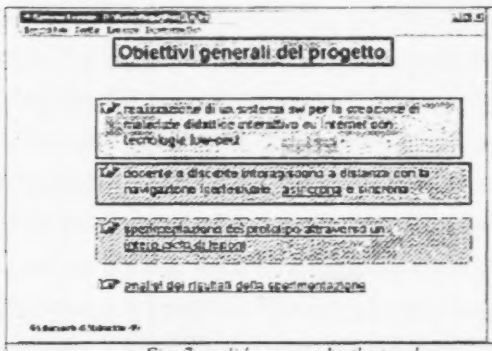

Fig. 7: a slide as seen by the teacher

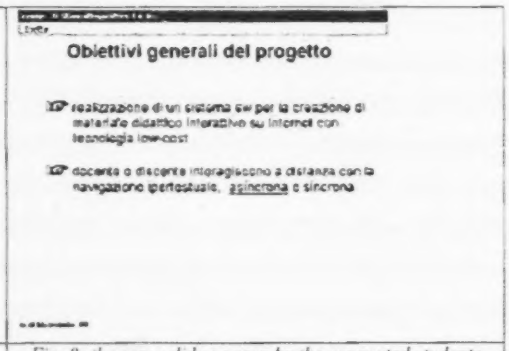

Fig. 8: the same slide as seen by the connected students

3.1. Technical data on the experiment

As said, one of the purposes of the project is to enable the use of low-cost technology, so that students who do not have costly videoconferencing equipment or fast communication lines can take part in lessons. Used for the experiment, therefore, were standard hardware and software components and low-speed communication lines: two Pentium II 350 PCs, a 64 Kb/s ISDN line, two standard low-cost webcams, two video projectors for slides and videos, NetMeeting™ 3.0 for the videoconference. Used to collect the data was a questionnaire comprising twelve open-ended questions designed to yield the following:

1. a general evaluation of the method and its suitability for teaching purposes;

2. a qualitative assessment of the teaching materials used by the teacher, in particular of the language used, the clarity of the slides and animations;
3. assessment of the quality of the audio component and of the importance or otherwise of the video component;
4. assessment of the pace and duration of the lesson: this being crucial for students accustomed to taking notes, etc, at the pace typical of a traditional lecture;
5. criticisms of aspects to be improved or changed;
6. an overall evaluation of the experiment and its improvement or otherwise between the first and last session;
7. judgements by the students according to their faculty and number of lessons attended: different backgrounds and different types of course may have introduced biases in assessments of the experiment.

4. Analysis of the replies to the questionnaire

Analysis of the (anonymous) replies to the questionnaire revealed considerable interest in, and appreciation of, the method and advantages of distance teaching. Detailed analysis of these aspects would be inappropriate here, given the evident disturbance effects arising from the novelty of the experiment and the close match between the experiment and the students' interests. Rather, we briefly review some aspects emerged from the questionnaire.

a. It was very apparent that a poor-quality audio signal was distracting for the students. By contrast, the quality of the video signal was less important than we had expected. It should be borne in mind that the quality of the video was rather unsatisfactory, given that the transmission rate was around 2/3 frames per second, and the size of the window was 160x120 pixels. This poor video quality was deliberately introduced so that we could ascertain the student's real interest in being able to see/distinguish the teacher's gestures, face and expressions. It seems as if the teacher's image was a contact with reality and nothing more, and that its non-intrusiveness was appreciated because it did not interfere with concentration on the contents of the slides.
b. The duration of the lesson (around 2 hours) was judged to be about right, although numerous students asked for a short break after the first hour, especially when complex matters were being dealt with. The information flow and stimuli were indubitably greater than those of a conventional lesson. Unfortunately, it was here that errors in gauging the pace of the lesson were most apparent, as explained below.
c. The tools for management of the lesson enabled the teacher to 'navigate' rapidly and efficiently through the teaching materials while supplementing them with a large amount of further information. The pace of the teacher's exposition should be carefully assessed and tested. The computer medium accelerates the transmission of information but hampers focusing on it by the students, and it does not give them enough time to take notes.
d. Again with regard to the pace of the lesson, the multimedia materials on the slides (generally images and animations) were regarded as essential for clarification, but the teacher was urged to synchronize the presentation of these materials with the time taken to read and understand them.
e. A large number of students said that that it was important to have printed materials on the topics addressed during the lesson, probably so that they could cope with the above-mentioned problem of note-taking.
f. The respondents stressed the importance of reducing communication via the microphone in the classroom or through a chat facility to the minimum. They also asked for interaction on the materials being used by the teacher. Instead, there was no request at all for some form of visual interaction, which confirms that video is only an accessory and unidirectional (teacher-to-student) aid.
g. Curiously but significantly, the students were reluctant to interrupt the teacher when he was present in the classroom, because this was deemed to clash with the purposes of distance teaching. Interruptions in a real classroom give the students time to pick up the thread of the argument, but in distance learning situations this 're-boot' is time-consuming and distracting.

We now provide some details concerning the analysis of the questionnaire replies. The teaching method used was judged to be 'satisfactory' or 'very satisfactory' by around 94% of the respondents, without marked differences between the two faculties. Most criticisms were expressed by those who had taken part in all four sessions: in this case, in fact, the students had sufficient information with which to express an opinion closer to the reality and less conditioned by the novelty of the method. The language used in the slides was regarded on average to be clear. The use of pictures, diagrams and animations was particularly appreciated (especially by the economics students). However, the replies highlighted the students' difficulties in taking notes while simultaneously following the teacher's explanations. This was because the pace of the simulations was much faster than that required to write examples on a blackboard. Consequently, the teacher had to alter the pace of his exposition so that the students had time to copy and understand the principles or concepts being presented.

The time aspect is generally little considered by electronic presentations. Moreover, the prototype for the remote control of lessons, given its technical characteristics, introduces practically no time-lag between the two remote components of the lesson. As a consequence, the delays that normally occur in distance communication are not possible in this case. As to the video transmission, this was regarded as useful but not indispensable by 79% of the economics students, but by only 50% of the engineering students. When opinions of the quality of the audio were analysed, account had to be taken of environmental conditions and of technical aspects. The two classrooms were of different sizes, the acoustics were also different, and a 64 Kb/s ISDN line was used for both the audio-video flow and the prototypes. This latter aspect was dictated by the need to verify the minimum conditions for satisfactory functioning of the system, this being indispensable for assessment of whether the lesson could be

followed by students at home, where the transmission band of the channel used is certainly not comparable to that of university networks. The data collected show that synchronization of the audio with the teacher's actions is of key importance. This is a very significant aspect, in that it makes the distribution of the audio in streaming format rather complicated. We had decided, in fact, to distribute audio/video in streaming format, due to the evident advantage of being able to exploit the multicasting characteristics of these technologies, and thereby reach a number of users with a single transmission. In the light of our preliminary experiments, and above all in view of the questionnaire results, we realized that besides the normal delay deriving from the remote transmission, streaming products introduce a further (and substantial) delay due to the streaming algorithms, which make this delay unacceptable. The assessments of the audio were decidedly positive, especially among the Economics students, whose classroom had better acoustics. Of course, the last thing we thought of in this complex experiment was to analyse the sound quality in the room where the students were sitting? Also interesting is analysis of the pace of the less and the speed at which arguments are expounded. There was a certain divergence between the opinions expressed on these aspects by the two groups: according to 35% of the economics students thought that the pace of the lesson was too fast, while the percentage fell to 13% among the engineering students, 4% of whom indeed declared it to be too slow (obviously influential here is the different levels of background knowledge in the two groups). One of the twelve questions on the questionnaire asked the respondent to indicate aspects to be improved, those to be changed, and functions to be added. The replies can be summarized as follows:

- To improve: the quality of the audio, synchronization between what the teacher is explaining and the slide being shown; some students wanted better video quality (but not a larger-sized window).
- Change: the pace of the lesson (according to the economics students), the characteristics of the rooms used for the sessions, the transmission band.
- Add: verbal interaction with the teacher, hard copies of slides to use during the session.

Conclusions

The paper has described the main results of an experiment in real-time distance teaching in which the teacher and learners interacted on teaching materials from physically distant classrooms. Used for the experiment was a prototype currently under development at the University of Trento, the aim of which is to set up an environment for the creation and management of on-line teaching materials. The experiment was positively evaluated by the students involved (21% very positive, 79% positive). None of the respondents expressed negative assessments of the experiment, and there were no significant differences between the results for the two faculties involved (Economics and Engineering). The experiment yielded some surprising findings on the usability of these systems with low-cost IT infrastructures. The students did not find fault with the extremely limited and qualitatively poor use of video, but they emphasised the need for improvement in the quality of the audio, and for adjustment in the pace of lessons. This clearly indicates that also the teacher should be 'trained' in how to manage lessons of this kind. Although they seem entirely similar to their traditional counterparts, the remoteness of the students and teacher interferes with the efficient conduct of the lesson, so that the teacher should learn how to overcome the differences in speed between the classrooms and his/her delivery.

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